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BISTATIC RADAR SYSTEM GRAPHICAL USER INTERFACE CALIBRATION AND MEASUREMENT DATA ANALYSIS AND DISPLAY COMPONENTS

CSC Professional Services Group

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1.0 Introduction

This final report is intended to serve as a starting point for anyone intending to continue the development of the Display and Performance Analysis Sections of Rome Labs's Bistatic Radar Systems Graphical User Interface (GUI) Controller.

The performance analysis and display sections of the system controller were nearly finished. The analysis and display capability was designed and the design is included. The components developed to date are documented. CSC suggests Rome Lab review this design and consider having someone complete the development. The components requiring completion could, for the most part, be developed by modifying the components developed to date. A few paths through the data analysis and display GUI are complete. The reader is urged to run the user walk through of these sections included in this document.

1.1 Overview

The Bistatic Radar System Graphical User Interface is intended to allow test engineers easy control and operation of the Bistatic Radar System being developed at Rome Lab. Of primary importance to the engineers is the ability to characterize the data acquisition components of the system. The characterization, done properly, allows post data acquisition digital signal processing to remove system errors and improve overall system performance. The data analysis and display components of the Radar System Controller were designed to provide a quick look capability to determine the quality and completeness of the data acquired.

Characterization is done as a step known as Calibration. During system calibration, known signals are inserted into the receiver system and each receiver channel is characterized. Calibration is repeated as often as necessary to minimize the system characterization unknowns that may change over time. Additionally, the test engineer needs the ability to monitor the changes, evaluate the completeness of the characterization and evaluate the probable improvement expected during digital signal processing.

Design of the data analysis and display capabilities went through a few iterations as the scope and purpose of the data analysis capability was investigated. The scope of the data analysis menu functions was limited to a kind of first look capability. The test engineer was to be able to determine what data had been collected and to evaluate preliminary channel balancing benefits. Additionally power spectrum signature analysis and antenna pattern performance analysis was desirable. To date the data completeness, accuracy and channel balance components have been defined and received most of the work.

2.0 Design

The data completeness and channel balance performance analysis components of the Bistatic Radar System Graphical User Interface are designed to allow the test engineer to view the data after the system has gathered either the calibration or measurement data and to perform preliminary channel balancing.

The design separated the support menu of the GUI into three components. The first is Setup Analysis, the second, Setup Display and the third is Display. The test engineer can click on Setup Analysis to select the data and analysis functions he or she desires, and then click on Setup Display to configure the display to configure or enhance the data display and finally click on Display to view the raw data or preliminary digital signal processed system performance. Appendix A of this document contains the Data Analysis Support Software Development Plan we were following.

For Calibration Data Analysis we envisioned the test engineer viewing each channel's calibration data. The digitally sampled, continuous or pulsed waveform I and Q components, Amplitude and Phase could be viewed as a function of time, channel and frequency.

Measurement data analysis was to be identical to the calibration data analysis capabilities. Channel Balance Performance analysis was to include after calibration channel flatness displays as a function of channel, and

frequency. Additionally the synthesized antenna receive pattern could be viewed before and after calibration and power signatures of the system developed and displayed.

3.0 Development Efforts

To initiate parallel development of the data analysis and display capabilities John Capanna made a copy of the MATLAB GUI main menu function measrsrc.m. The data analysis and display function developed to date have been added to that copy. The menus will have to be integrated with John's latest version of measrsrc.m

As of the end our development efforts, no actual calibration or measured data was available to process through the analysis components of the GUI. To support development and testing of the analysis and display menus, I developed MATLAB code to read calibration and measurement header files, get the test case variables and data definitions, and generate representative calibration and measurement data.

The analysis request sub-menu has been coded and tested and is contained in the file setanal.m. To support the analysis requests, individual display GUI's were to be developed to provide two and three dimensional plots of either raw or processed data. The raw calibration or measurement data is displayed as either In-Phase, Quadrature, Amplitude or Phase of the channels received signal as a function of Time, Frequency or Channel Number. Menu components of the Display GUI's allow the user to select a sub-section of the calibration, measured or channel balanced data to be viewed. The user could select a frequency range, channel or number of channels to be viewed.

The two dimensional time data display request sub-menu GUI has been coded and is contained in the file ct2ddispm. The Analysis Setup Menu controller GUI component selects this MATLAB function if the analysis requests indicate that type of data is to be analyzed. The other analysis and display functions were to be developed as contained in the software development plan.

The first analysis capability is operational and can be evaluated by performing the following operational walk through.

4.0 Operational Walk Through

The tester is directed to the directory - C:\matlab\bistatic on the 33 MHz Personal Computer in the Bistatic Radar System Development Lab. There he or she can walk through the capabilities developed to date.

Walk through:

Start Matlab from the window Matlab icon.
Enter - cd bistatic
Enter – initmain

The function initmain initializes the global calibration and measurement data structures and indices. It also reads an example calibration data header file and generates representative calibration data and starts the main measurement GUI, measrsrc.in.

Select Set Up Analysis from the main menu.

This runs the setanal.m function to get the user selection of data type, plot type and analysis type.

Select Calibration data type, Time as the plot independent variable and In-Phase vs. Time, step Frequency, step Channel # for the analysis type.

Select Run Display from the menu options.

This starts the display function as selected by the analysis setup. In this case the calibration data vs. time

two dimensional data display GUI function `ct2ddisp.m` is called. The `ct2ddisp` GUI function sets up all the call backs to allow the users to travel backward through the GUI options, sets up the frequency and channel user selection sliders and displays the initial calibration data plot by calling `plott2d.m`. The user can change the frequency and channel sliders and observe that data on the display plot.

Select **Set Up Analysis** from the menu. Change the analysis type to any of the listed types and repeat step 6. Notice the data has changed to the data selected.

This analysis and data display combination is the only working combination coded to date. The other display functions can be quickly developed by copying and modifying the `ct2ddisp` and `plott2d.m` functions.

5.0 Function Descriptions

The major MATLAB functions developed for the performance analysis and data display components are listed by their MATLAB m-file names. After each name a short description is included. For the most part they are listed as they are encountered during operation.

`initmain.m`

This function is a support function used to initialize data storage variables, set default selections and generate representative calibration data and start the main menu function `measrscr.m`

`measrscr.m`

This function is discussed in detail in John's report. I have programmed the **Set Analysis** and **Run Display** GUI buttons of this menu to be active. The display of the menu options stay visible throughout the operation of **Setup Analysis** and **Run Display**. This is accomplished by having the following GUI functions continue to display all the buttons and support the buttons that are considered active at the time.

`gencal.m`

Called by `initmain.m`, this functions reads a default calibration header file to get the parameters over which it will generate a test calibration data set. The measurements system is modeled with transmission lines, line losses and measurements receiver noise to generate an example calibration data set.

`setanal.m`

Called by `measrscr.m`, this function generates a main menu of buttons and a calibration file select button and a measurement file select button along with the data type, plot type and analysis type pull down menus. The user uses the buttons and pull downs to select the calibration, measurements and analysis desired. From this menu the user can request **Run Display** and this will cause the function to choose the correct display function to support the desired analysis.

`ct2ddisp.m`

Called by `setanal.m` when time based calibration data is to be displayed by a two dimensional plot. This function generates the frequency and channel number sliders the user can use to modify the frequency and channel of the calibration data displayed.

`plott2d.m`

Called by `ct2ddisp.m` this function supports plotting all two dimensional calibration data. The plot title and plot labels are stored internally and selected as specified by the input plot type parameter.

Appendix A

Data Analysis Support Software Development

Analysis Menus

1. Setup Analysis
2. Setup Display
3. Display

Purpose

Select Data and Analysis Functions
Select Display Options
Display the data under analysis

User Activity Program Flow

Setup Analysis Selected

Get Data Type

Calibration

Fill Calibration Structure

Get Calibration Name - Read Calibration Header
Record Calibration Information - Modulation Type
Generate time, frequency, channel vectors
Read and Record Calibration Data for all Channels
Complex Data (I and Q) (time vs. frequency vs. channel)
Generate (I, Q, A, P)

Get Calibration Analysis Function Selection

Sampled Calibration Data -- (I, Q, A, P) t, f, c
Get Data Combination to Display - - (I, Q, A, P) (t, f, c)
Time Average Calibration Data -- (A, P) (f, c)
Get Data Combination to Display - - (AP) (f, c)
Channel Balance Factors -- (Gain and Phase Shift) f, c
Get Data Combination to Display - - (G, PS) (f, c)

Measurement

Fill Measurement Structure

Get Measurement Name - Read Measurement Header
Record Measurement Information - Modulation Type
Generate time, frequency, channel vectors
Read and Record Measurement Data for all Channels
Complex Data (I and Q) (time vs frequency vs channel)
Generate (I, Q, A, P)

Get Measurement Analysis Function Selection

Sampled Measurement Data - - (I, Q, A, P) t, f, c
Get Data Combination to Display - (I, Q, A, P) (t, f, c)
Time Average Measurement Data (A, P) f, c
Get Data Combination to Display -- (A, P) (f, c)

Channel Balance Performance

Fill Calibration and Measurement Structures as above.

Get Balance Performance Analysis Function Selection

Antenna Pattern -- (Gain) f
Get Data Combination to Display - - (Gain) (f)
Power Spectral Signatures (before and after cal) - (Power) f, c
Get Data Combination to Display - - (Power) (f, c)

Setup Display Selected

Show data extents

Modify Default Display Settings-

Display Center	Defaults
Time Since Trigger	Middle of Sample Window
Frequency (MHz)	Middle
Channel #	Middle
Antenna Pattern Angle (degree)	Center
Display Width	
Time	All
Frequency (MHz)	All
# of Channels	All
Antenna Pattern Angle Width (degree)	All

Display

Display the calibration or measurement data - (I, Q, A, P) t, f, c

- 2d In-Phase vs. Time step Frequency step Channel #
- 2d Quadrature vs. Time step Frequency step Channel #
- 2d Amplitude vs. Time-step-Frequency step Channel #
- 2d Phase vs. Time step Frequency step Channel #
- 2d Combo vs. Time step Frequency step Channel #

- 2d Avg. Amplitude vs. Frequency step Channel #
- 2d Avg. Phase vs. Frequency step Channel #
- 2d Combo vs. Frequency step Channel #

- 2d Avg. Amplitude vs. Channel # Step Frequency
- 2d Avg. Phase vs. Channel # Step Frequency
- 2d Combo vs. Channel # Step Frequency

- 3d Amplitude vs. Frequency vs. Channel # - tilt and rotate
- 3d Phase vs. Frequency vs. Channel # - tilt and rotate

Display the Channel Balance data -- (G, PS) f, c

- 2d Balance Gain vs. Frequency Step Channel #
- 2d Balance Phase Shift vs. Frequency Step Channel #
- 2d Balance Gain vs. Channel # Step Frequency
- 2d Balance Phase Shift vs. Channel # Step Frequency

Balance Performance Data

- 2d Antenna Pattern (Gain) vs. Beam Steer Step Frequency
- 2d Modulation Power Spectral Signatures (before and after cal)
--Power vs. Frequency step IF step Channel #